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Influence of mineralogy on Sporosarcina pasteurii attachment in engineered and natural porous media

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Microbially-induced carbonate precipitation (MICP) has demonstrated promise in a variety of subsurface applications including immobilization of groundwater contaminants and remediation of leakage pathways associated with CO2 sequestration. In order to implement MICP at the field scale, however, the injection strategy must be tailored for efficacy in natural, heterogeneous porous media. Specifically, the overlapping effects of varied mineralogy and pore geometry on bacterial attachment, growth, and mineralization must be fully resolved. While the affinity of microorganisms for certain minerals (e.g. carbonates and clays) over others (e.g. silicates) is established, and biomass growth rate is known to be mediated by variables such as pH, such insights must be synthesized to develop injection strategies that produce desirable quantities and distributions of precipitate.

In this study, we investigate four questions pertaining to the influence of mineralogy on final precipitate distribution in a typical MICP injection consisting of separate attachment, growth, and mineralization phases. First, we assess to what extent initial biomass distribution is correlated with mineralogy. To this end, we construct modular columns to resolve average attachment rate versus distance from inlet; attachment rates are then determined experimentally for a set of common minerals including silica sand, kaolinite, Na-montmorillonite, and natural limestone grains, with parameters including grain size distribution, flow rate, and pH held constant. Second, we examine the correlation between final precipitate distribution and initial biomass distribution; this is accomplished by post-MICP characterization of columns via X-ray computed microtomography (XCT) for spatially-resolved precipitate distribution. Third, we attempt to decouple final precipitate distribution from initial biomass distribution through two modifications to the growth stage of injection. These include mechanical redistribution of biomass through rapid flow-induced shear sloughing, and slowing of biomass growth rate near the inlet via influent media acidification. Finally, we determine whether these modifications remain effective when applied to natural cores of clay-rich sandstone, whose pore size distribution differs from the engineered columns. Taken together, these experimental results elucidate the influence of mineralogy on the distribution of precipitates for typical MICP processes, and suggest avenues for optimizing injection strategy given mineralogy.

Participation

In-Person

References

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